

CLAIMS

Having thus described the aforementioned invention, we claim:

5 1. A method for improving spatial resolution using on-line depth-of-interaction (DOI) rebinning in a hybrid Positron Emission Tomography (PET)/Single Photon Emission Computed Tomography (SPECT) system running in PET-mode, the PET/SPECT system having a rotating dual-head tomograph using LSO/NaI scintillators and being capable of depth-of-interaction (DOI) measurement, the tomograph defining a field of view (FOV) within a patient gantry, said method comprising the steps of:

- 10 (a) acquiring a PET coincidence data stream from a patient scan;
- (b) delivering the PET coincidence data stream to an on-line rebinner to derive a bin address output stream;
- (c) deriving a bin address output stream in said on-line rebinner from said PET coincidence data stream;
- 15 (d) delivering the bin address output stream from the rebinner to a Fibre Channel PCI DMA receiver card for direct PCI DMA stream transfers;
- (e) histogramming the bin address output stream; and
- (f) storing said bin address output stream.

2. The method of Claim 1 wherein said on-line rebinner is integrated within a rebinner circuitry which supports on-line real-time DOI line of response (LOR)-to-projection-space nearest-neighbor rebinning, and wherein DOI and gamma interaction centroid depth knowledge about LOR positioning is applied in real time.

3. The method of Claim 1 wherein said step of deriving said bin address output stream includes performing a transaxial computation to determine at least a sinogram angle and a radial offset of a coincidence event between a first detector having coordinates  $(x_A, y_A)$  of a first detector head and a second detector having coordinates  $(x_B, y_B)$  of a second detector head, wherein said sinogram angle is determined by the equation:

$$sa = \tan^{-1} \left[ \frac{y_b - y_a}{x_b - x_a} \right],$$

and where said radial offset is determined by the equation:

$$ro = \sqrt{(x_a^2 + y_a^2)} * \sin(\tan^{-1}(y_a / x_a) - sa).$$

4. The method of Claim 1 further comprising the step of measuring a Gamma centroid location including the steps of:

- (1) rastering assumed transaxial and radial head positions and a corresponding rebinning map for optimal back-

5 projected image resolution, said step rastering using variables  $r_A$ ,  
 $t_A$ ,  $r_B$ ,  $t_B$  to represent radial and transaxial offsets for each head of  
the dual-head tomograph; and

10 (2) stepping the values for  $r_A$ ,  $t_A$ ,  $r_B$ ,  $t_B$  discretely  
through a chosen range, with all combinations of the variables  
being tested.

5. The method of Claim 1 further comprising the step of  
finding an optimal position of each head of the dual-head tomograph  
including the steps of:

- 5 (1) collecting a 64-bit list mode file;  
(2) assuming a crystal position as the centroid for each  
head; and  
(3) defining a sequence for varying the assumed crystal  
positions.

6. The method of Claim 5 wherein said sequence for varying  
the assumed crystal positions includes the steps of:

- 5 (i) making at least one rebinning look up table;  
(ii) rebinning list mode data;  
(iii) histogramming and reconstructing the  
image;  
(iv) assessing image resolution using Full Width  
Half Maximum (FWHM) resolution;

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(v) recording a best resolution number and an associated trial position variable; and

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(vi) repeating said steps of rebinning list mode data through said step of recording a best resolution number and an associated trial position variable on a subsequent trial variable set.

7. The method of Claim 6, in said step of assessing image resolution, wherein all FWHM resolution numbers are assessed from a conventional 2-D filtered back projection of the sinogram using a ramp filter with a 0.5 cutoff.

8. The method of Claim 6, in said step of assessing image resolution, wherein both image horizontal and vertical FWHM assessments are performed.

9. The method of Claim 6 further comprising the step of defining a final rebinning look-up table to be applied for general use, including for LOR which do not serve the FOV center.

10. A method for improving spatial resolution using on-line depth-of-interaction (DOI) rebinning in a hybrid Positron Emission Tomography (PET)/Single Photon Emission Computed Tomography

(SPECT) system running in PET-mode, the PET/SPECT system having a rotating dual-head tomograph using LSO/NaI scintillators and being capable of depth-of-interaction (DOI) measurement, the tomograph defining a field of view (FOV) within a patient gantry, said method comprising the step of:

finding multiple gamma interaction centroid locations which are unique for different line of response (LOR) incident angles.

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